AMPLIFIERS

Amplifiers are used in just about all electronic circuits. In audio equipment, the input to the receiver is too small to power the speaker system, so it must be amplified before it is sent to the speaker. The same is true with video equipment, the input signal must be amplified before it can be presented on a Cathode Ray Tube (Picture tube). In this block of instruction, you will see the basic types of amplifiers and how they operate.

Before starting into the operation of amplifiers, there are some definitions that must be explained to simplify the explanations as the theory is explained.

AMPLIFIER - Amplifiers are devices that provide amplification without appreciably altering the original signal.

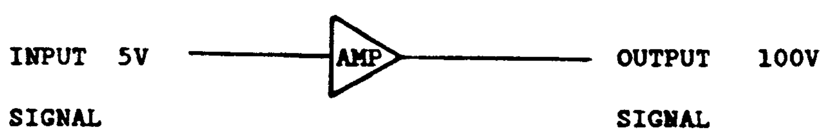
AMPLIFICATION - Amplification is the process of increasing the strength of a signal. (Increasing the current, voltage and power of the signal).

AMPLITUDE - The amplitude of a signal simply describes the size of the signal (The amplitude of a sine wave is 20VAC P/P).

GAIN - Gain is the comparison of the amount of signal entering the active component to the amount of signal leaving that component.

ACTIVE COMPONENT - Active components or devices are vacuum tubes, transistors or integrated circuits.

The main purpose of an amplifier is to provide an increase in the signal strength. This increase in signal strength is called gain. By using a simple formula anyone can determine the gain of an amplifier. If the input signal is measured and recorded, the gain is determined by dividing the input signals amplitude into the output signals amplitude. In the example below, the input is 5 volts and the output is 100 volts, thus the gain would be 20.



$$\text{GAIN} = \frac{\text{OUTPUT SIGNAL}}{\text{INPUT SIGNAL}}$$

$$\frac{100V}{5V}$$

20

FIGURE 1

Notice the amount of gain is listed with just a numerical value. The voltage designators have been dropped. Also the symbol for an amplifier is shown as a triangle. Anytime an amplifier is shown on a schematic it will be drawn as a triangle. Each time a signal is amplified it is said to go through a stage of amplification. A schematic triangle may represent one or more stages of amplification. The example in Figure 2 shows one of the primary uses of an amplifier.

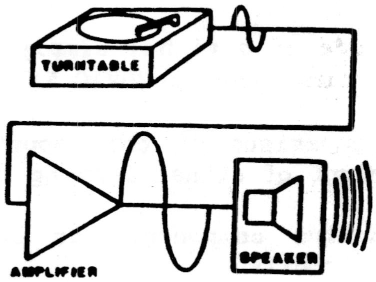


Figure 2

CLASSIFICATION OF AMPLIFIERS: Most amplifiers can be classified in two ways. The first classification is by their function, this means they are basically voltage or power amplifiers. The second classification is by frequency response, this means they are designed to amplify certain frequencies.

VOLTAGE AND POWER AMPLIFIERS

Voltage Amplifier: A voltage amplifier is an amplifier in which the output voltage is larger than the input voltage.

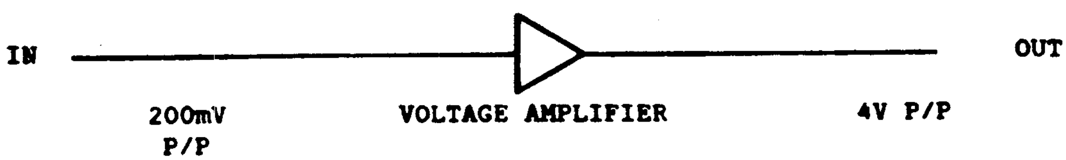
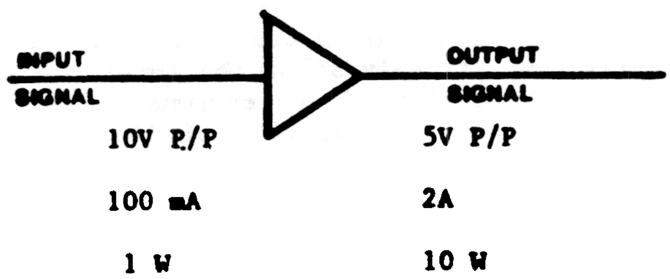


Figure 3

Power Amplifier: A power amplifier is an amplifier in which the output signal power is larger than the input signal power.



POWER AMPLIFIER

Figure 4

Frequency Amplifiers: These amplifiers are classified by frequency response. The frequency response of an amplifier refers to the band of frequencies or frequency range the amplifier was designed to amplify. The components of an amplifier will respond differently at different frequencies, so any one amplifier cannot amplify all frequencies. The transistor will have frequency limitations and respond in different ways as the frequency changes. The components of the circuit (capacitors and inductors) will also change their reactance as the frequency changes. Since the components of an amplifier varies with the frequency, specific components are selected to amplify certain frequencies. There are three categories of frequency amplifiers; An Audio Amplifier, Radio Frequency Amplifier, and Video Amplifier.

Audio Amplifier - An Audio Amplifier is designed to amplify the entire band of frequencies contained in the audio range. These frequencies range from 5Hz to 20KHz.

Radio Frequency Amplifier - A RF Amplifier is designed to amplify frequencies between 10KHz to 100,000MHz. A single amplifier cannot amplify all of these frequencies, so any amplifier designed to amplify a frequency within this range is called a RF Amplifier.

Video Amplifier - A Video Amplifier is designed to amplify a band of frequencies between 10Hz and 6MHz. These amplifiers are sometimes called WIDE-BAND AMPLIFIERS because of the very wide band of frequencies that are amplified, these amplifiers do not have as good of gain as the narrow band amplifier. It also has many more components than the narrow band amplifiers.

TRANSISTOR AMPLIFIERS: Transistor Amplifiers are current control devices. The amount of current in the base of a transistor controls the amount of current in the collector. The secret to understanding amplifiers is to remember the fact that current controls the gain. If the current is controlled in the amplifier then the output voltage can be controlled simply by decreasing or increasing the current that flows through the transistor. The base current of a transistor can control the current flow through the collector. If only 5% of the total current flows through the base, then this small portion of the current will control the entire operation of the transistor. The capacity of the smaller base current flow to control the larger collector current flow is the basic concept of a transistor amplifier.

Frequency Response of Amplifiers.

Amplifiers are also classified by frequency response. The frequency response of an amplifier refers to the range of frequencies the amplifier was designed to amplify. Due to the components that compose an amplifier, it is impossible to construct an amplifier that will amplify frequencies at 100 hertz and 1000K hertz in the same manner. The amplifying device, the transistor, will have some frequency limitations and will respond in different ways to frequency changes. Also the capacitors and inductors of the circuit will change reactance as the frequency changes. There will also be slight amounts of capacitance and inductance between the circuit wiring and the other components within the circuit. This capacitance is called stray capacitance, shunt capacitance or interelectrode capacitance.

This capacitance is capacitances between connecting wires and ground. Also, transistors have these capacitances between their terminals. All these capacitances are very small, so that at low and medium frequencies their impedances are very high. As frequencies increase, the impedance of these capacitances fall. When the impedance is small enough, they begin to shunt away some of the input and output currents and thus reduce the gain of the amplifier. The inductance found in electronic circuits are called lead inductance. This inductance is produced by the leads going into the resistors. This inductance is approximately .02 microhenrys per inch of wire commonly used in electronic circuitry. (AWG 18 to 26) This inductance can affect the amplifier circuit by reducing the amplitude of the signal. If a piece of wire in the circuit is 7 inches long, it will have an inductance of .14 microhenrys. With this small amount of inductance, if the input signal frequency is 10Mhz, the inductive reactance is 8.79 ohms.

These inductances and capacitances may or may not affect the circuit operation. It depends on the resistance and the frequency of the circuit.

Capacitors also have lead inductance and they will form a resonant circuit at certain frequencies. For instance, if a capacitor is valued at 47 microfarads and has leads of one inch, it will become resonant at

164Khz. This is found by using the resonant Frequency formula, $f_R = \frac{1}{2\sqrt{LC}}$ Under these conditions, if the frequency of the circuit becomes higher than 164Khz, the capacitor will no longer act like a capacitor but will act like an inductor.

Amplifier Classes of Operation

The class of operation of an amplifier is determined by the amount of time the current flows in the output circuit when compared to the input signal. There are four classes of operation; A, AB, B, and C. Each of these classes has certain uses and characteristics, but no one class of operation is considered to be better than another class. The selection of the class to use is determined by the use of the amplifier. The best class of operation for a audio amplifier would not be the same as for a radio oscillator.

CLASS A.

REFER TO FIGURE 5.

CLASS A

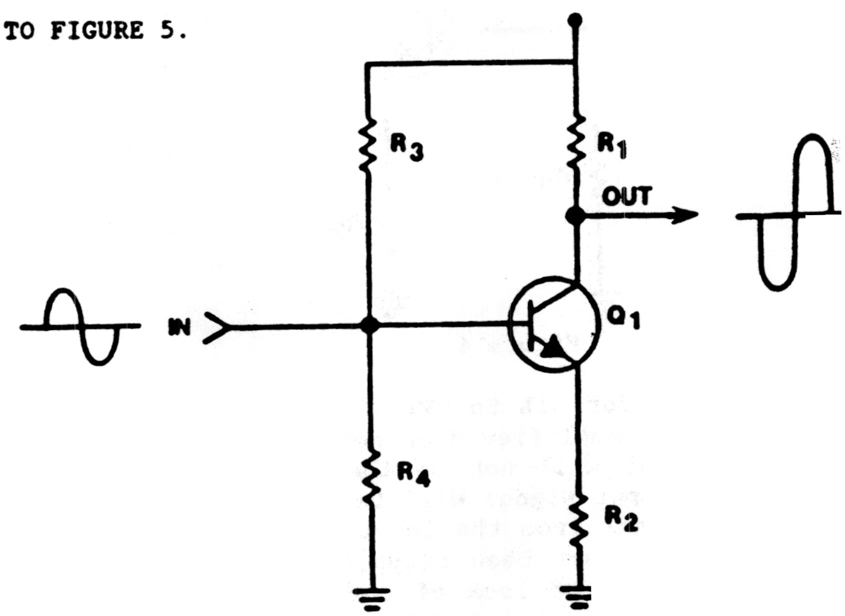


Figure 5

In a Class A Amplifier, current will flow in the output for 100% of the input signal. The output is a 100% copy of the input signal except the amplitude has increased. This is one of the characteristics of Class A Amplifiers and is called FIDELITY. Fidelity means the output is just like the input except for the amplitude. The output has the same shape and frequency as the input. It is possible in some cases to have a phase shift between the input and output signals but the shape and frequency would still be the same. Another characteristic of Class A Amplifiers is low efficiency. Efficiency of an amplifier refers to the amount of power delivered to the output compared to the power used to operate the amplifier circuit. If the Class A Amplifier has current flow for 360 degrees of the input signal, then it will operate all of the time. With the circuit operating continuously, it will take more power to operate than a circuit that operates for 180 degrees of the input signal or about half of the time. Thus a Class A Amplifiers characteristics are good fidelity and low efficiency. In a Class A Amplifier the low efficiency is acceptable because the efficiency is not as important as good fidelity.

CLASS AB AMPLIFIER

REFER TO FIGURE 6.

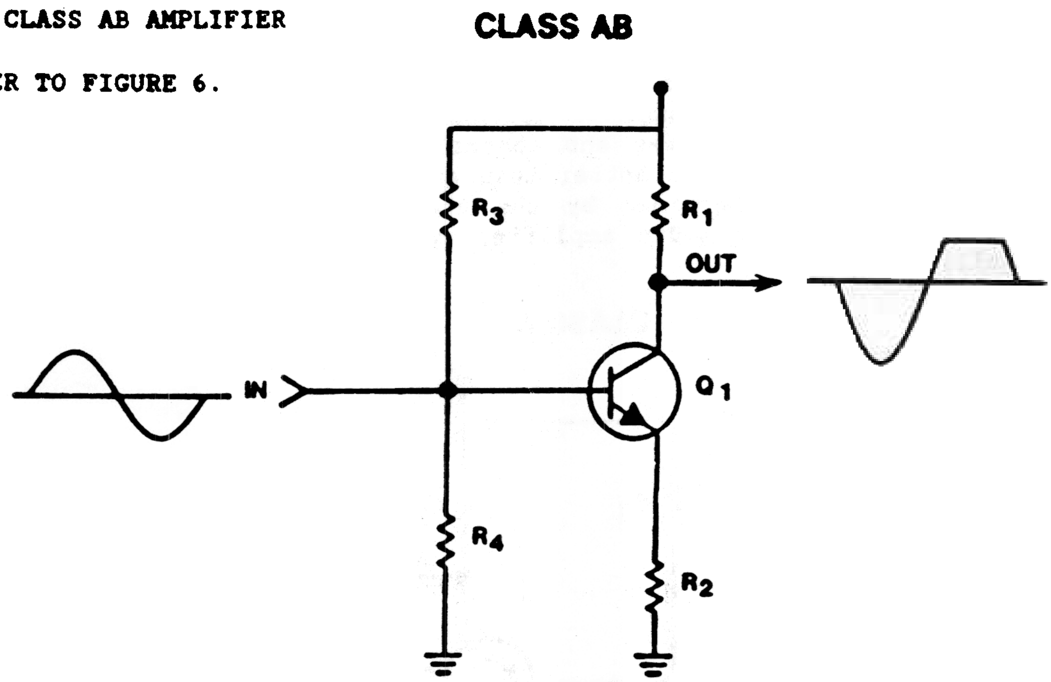


Figure 6

If the amplifier operates for 51% to 99% of the input signal, it is a Class AB Amplifier. Since the amplifier does not operate for the complete input cycle, the output signal will not be the same shape as the input signal. In this case, the output signal will be distorted. Distortion is any undesired change in a signal from the input to the output. Referring to Figure 6, the output signal has been clipped off during the positive alternation. This is caused by the lack of current through the transistor. When the base becomes negative enough, the base-emitter junction will be reverse biased and cuts the transistor off. From the cutoff point of the transistor, any increase in the input will not cause an increase in the output signal. The efficiency of the Class AB Amplifier is better than that of a Class A Amplifier because it does not operate for as long of time. The fidelity of a Class AB Amplifier is not as good as the fidelity of a Class A Amplifier because of the distortion in the output signal.

CLASS B AMPLIFIERS

REFER TO FIGURE 7.

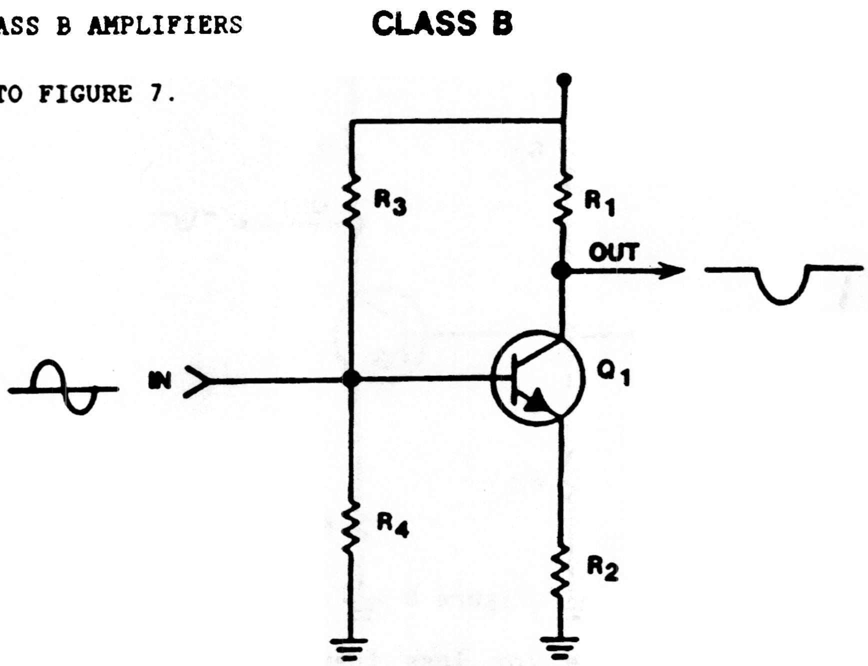


Figure 7

Class B Amplifiers operate for 50% of the input signal. The base-emitter bias will not allow the amplifier to operate when the input signal become negative, so the only time the transistor will conduct is during the positive alternation of the input signal. In the case of a Class B amplifier, the base/emitter junction is biased at or near cutoff in the static mode. As the positive portion of the input signal is applied to the amplifier, it will forward bias the amplifier and the positive half of the input signal will be amplified and inverted at the output. The negative portion of the input will reverse bias the amplifier and it will cut off. For the entire time, the negative half of the input is applied to the transistor it will remain cutoff and there is no output signal. The output signal will look similar to the output of a rectifier, but remember that a Class B Amplifier will amplify the portion of the signal that is being reproduced and a rectifier will not amplify. A Class B Amplifier is twice as efficient as a Class A Amplifier because it only operates for 50% of the input signal. Fidelity is low because only half the input signal is being reproduced. Class B Amplifiers are used in cases where only half the input signal is needed.

CLASS C AMPLIFIERS

REFER TO FIGURE 8

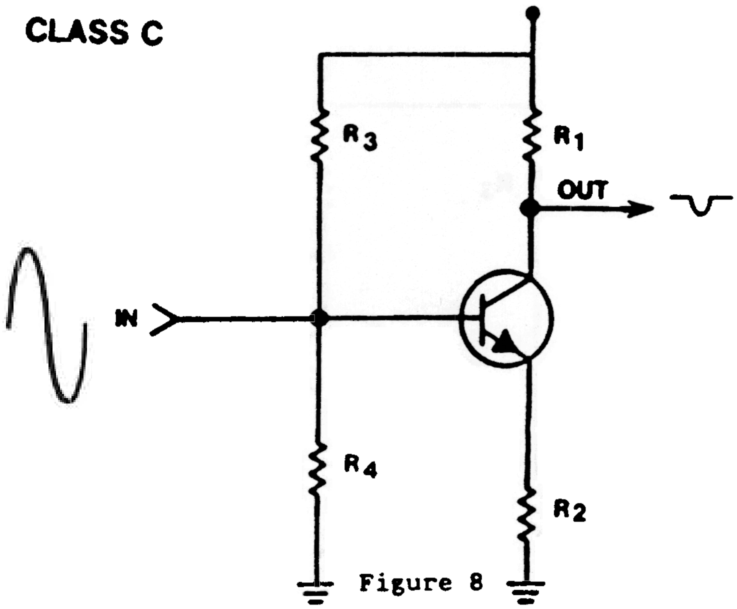


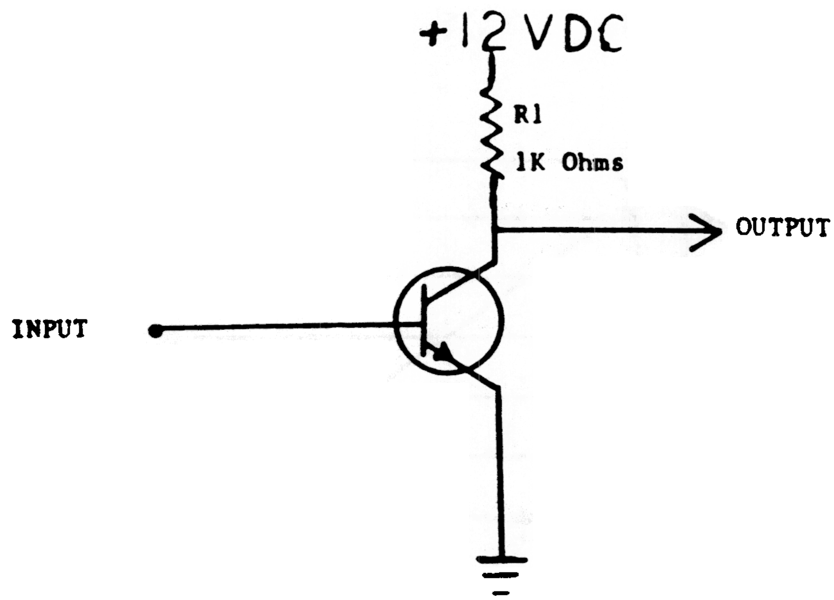
Figure 8

Class C Amplifiers operate for less than 50% of the input signal. Class C Amplifiers are used when only a small portion of the input signal is needed. Class C amplifiers are biased below cutoff. This means that the emitter/Base junction is actually reverse biased. Assume the emitter/Base was reversed biased by 200 mV. If a signal was applied to the base the positive alternation would have to go at least 200 mV positive before the transistor would turn on. After the transistor was finally forward biased, it would then amplify the remaining portion of the positive alternation. However, when the positive alternation decreases to the point it can no longer hold the transistor conducting, it will turn off. We see then that the transistor will conduct for less than 180°. It produces only a small portion of the input signal. It operates for a very small portion of the input so it is the most efficient of all classes of amplifiers and it has the worst fidelity.

LOAD LINE DEVELOPMENT

Remember, one of the most important characteristics of a transistor is the ability to regulate current flow and that the base current can control the current in the collector. In an amplifier, the goal is to take a small input signal and change it to a large output signal. To insure proper amplification will be achieved in a transistor, a set of characteristic curves is used to identify the operating range of a transistor. During the basic transistor lesson, characteristic curves and load lines were explained in detail, if any questions concerning either of these are encountered refer to that lesson for an explanation. The set of characteristic curves gives the maximum values for a specific transistor. An operating point is chosen for the transistor and biasing is established. The operating point must be within safe limits of the characteristic curve or distortion will occur. To operate the transistor within the linear area to prevent distortion, a load line is developed on the curves. The load line is developed from two assumptions; one is the transistor is saturated and the other is the transistor is cutoff.

REFER TO FIGURE 9.



Looking at the output, if the transistor is cutoff, there will be no output and the collector voltage will be +12VDC with 0 amps of current. This establishes one of the starting points to develop the load line. If a positive signal is placed on the base, the transistor will conduct and go to saturation. At this time, the output will be near zero volts and the current will be maximum. The current can be established by using the resistance and voltage of the circuit. When the transistor is saturated, the resistance of the collector-emitter junction will be extremely low or near zero. With this condition, the only resistance will be the collector resistor. Using Ohms Law to determine current, divide the Vcc by the resistance of R1. This means the maximum current will be 12mA. With this information, the characteristic curve and the load line can be established.

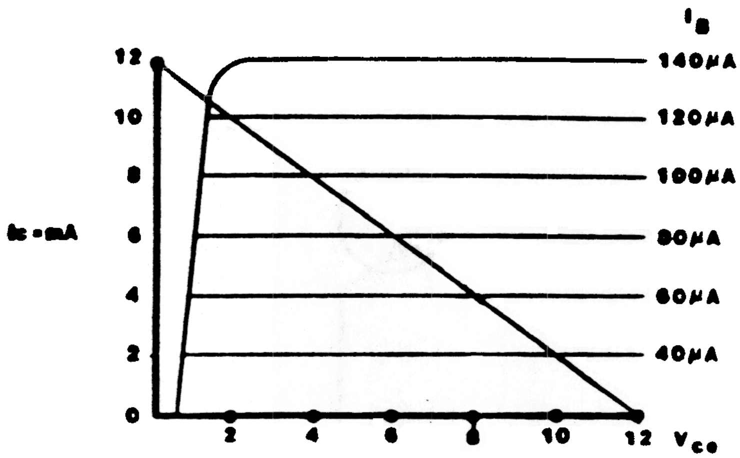


Figure 10

If the information above is placed on the characteristic curve, a point will be established for the cutoff and the saturation condition of the transistor. The first point was under the cutoff condition and the current on the collector was 0mA and the voltage was 12V on the collector. If that spot is located on the characteristics curve, it would be point A. The other condition was saturation, that is, maximum current on the collector (12mA) and minimum voltage (approximately zero). This will be at point B. If a line is drawn between point A and point B, it will be the load line for this transistor. The amplifier can be operated at any point along this load line. At different points along the load line you can determine the class of amplifier.

With the load line established, an operating point can be determined by applying a known current on the base of the amplifier. For instance, if 100uA is applied to the base, then the current and voltage can be determined for the collector. See figure 11.

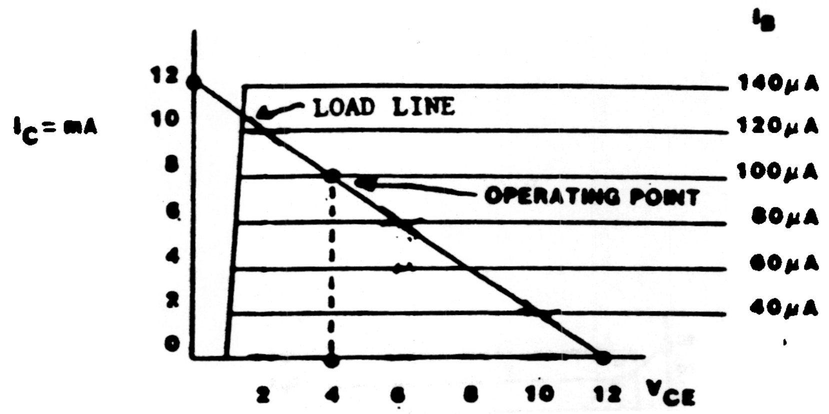


Figure 11

With 100uA applied to the base, the collector-emitter voltage will be 4VDC and the collector current will be 8mA.

To operate an amplifier in the linear region, an operating point must be established for the amplifier to avoid moving the operating point beyond the saturation and the cutoff points. If an input signal is applied to an amplifier that causes the amplifier to exceed either the cutoff or saturation point, the output signal will be distorted.

REFER TO FIGURE 12

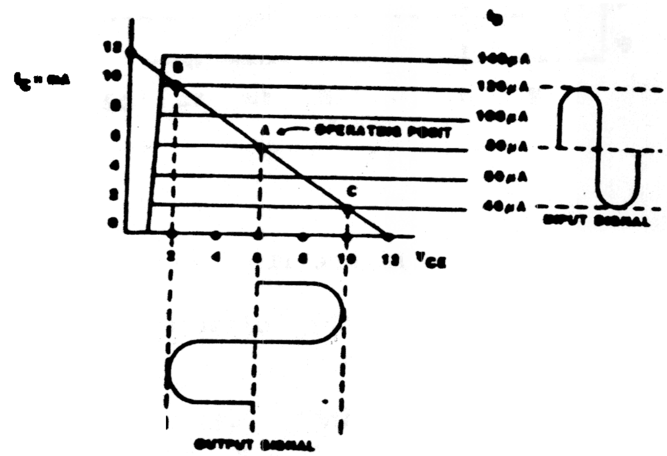


Figure 12

To operate an amplifier in Class A operation, the operating point must be located approximately at the center of the load line and the input signal must be established along the linear portion of the load line.

With the operating point established at 80uA of base current and the input signal varying from 120uA to 40uA, the characteristics of the output signal can be determined. If the operating point is when 80uA is applied to the base, locate Ib 80uA on the characteristic curve and follow the line to the left until it intersects the load line, which is point A. If the operating point is at point A, then the collector current will be 6mA and the collector-emitter voltage will be 6V. If the positive portion of the input signal rises to 120uA, trace that point to the left until it intersects the load line (point B), the collector current has increased to 10mA and the collector-emitter voltage has decreased to 2VDC. This is the maximum current the collector will feel with this signal applied, so the amplifier will never reach saturation. For the negative portion of the input signal the Ib will decrease to 40uA, by following this line to the point it intersects the load line the minimum collector current can be determined (point C). At this point the collector current has decreased to 2mA and the collector-emitter voltage has increased to approximately 10VDC. Notice the amplifier never reaches cutoff. It has been determined that the output signal will vary from 2VDC and 10mA to 10VDC and 2mA. The input signal had a current ranging from 40uA to 120uA on the base and the output signal has a current ranging from 2mA to 10mA. This proves that the current will be amplified greatly and the output signal will be a copy of the input signal. This amplifier will be operating 100% of the time and the output signal has no distortion, so with these conditions this would be a Class A Amplifier.

REFER TO FIGURE 13.

If the operating point is moved in either direction along the load line, the class of the amplifier will probably change. Notice in Figure 13 the operating point has been moved from 80uA to 40Ua and the input signal remained the same as in figure 12.

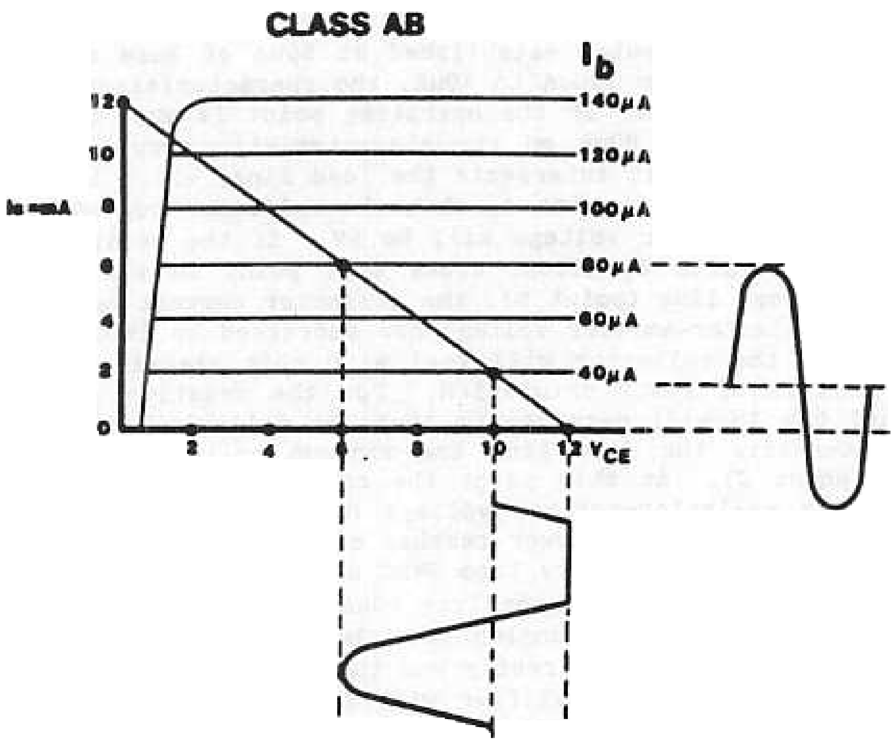


Figure 13

For the positive alternation of the input signal, the amplifier will conduct and develop an output signal. The negative alternation of the input signal will cause the amplifier to cutoff for a portion of the signal. Now the amplifier is no longer operating in the Class A Mode, but does operate in Class AB Mode.

If the operating point was moved further down the load line towards the cutoff point, the amplifier would operate in Class B or Class C Mode.

AMPLIFIER CONFIGURATIONS

Transistor Amplifiers may be connected in any one of three basic configurations. They are the Common Emitter (CE), Common Base (CB), and Common Collector (CC). They are the very basic amplifiers but the theory can be used for most amplifiers. The term common (or grounded) indicates that the particular element of the transistor is associated with both the input and output signals.

COMMON EMITTER AMPLIFIER

In the Common-Emitter Amplifier circuit, the input is applied to the base-emitter leads and the output is taken from the collector-emitter leads. Most Common Emitter Amplifiers have voltage gains of 300 to 1000 and the output signal is 180 degrees out of phase from the input signal.

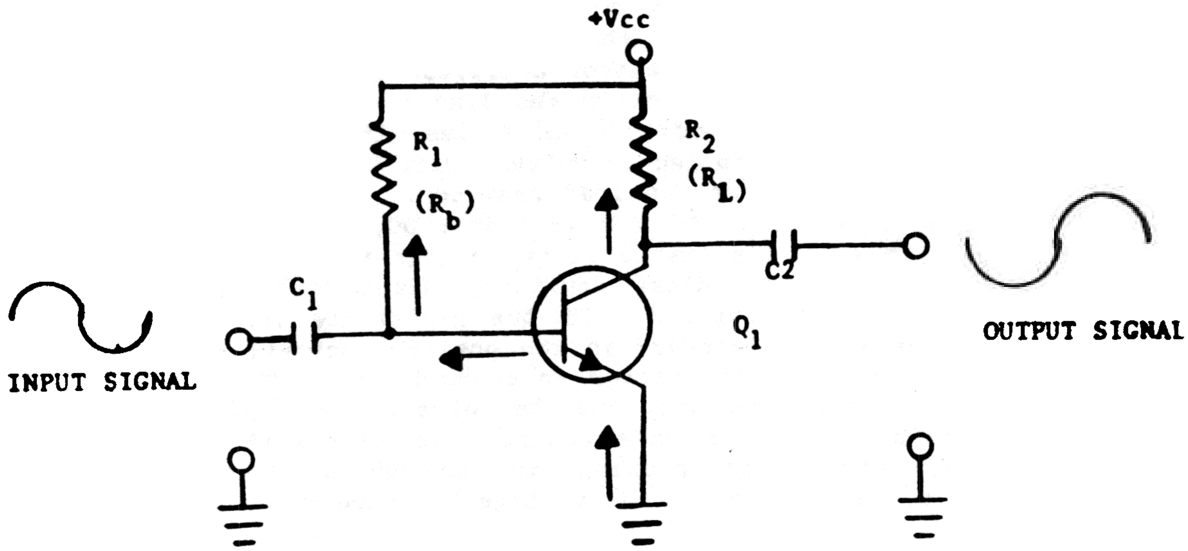


Figure 14

Before starting with the circuit theory, a few terms should be explained.

STATIC STATE OF A TRANSISTOR - The static state means the DC biasing voltage is applied but no input AC signal is applied. The transistor is in a steady state (not varying). The transistor may be conducting or cut-off, depending on the bias on the transistor.

DYNAMIC STATE OF A TRANSISTOR - This describes a state of operation when the transistor has the DC bias voltage applied and has an AC signal applied to the input.

Rb - The base resistor is used to develop the bias voltage on the base of the transistor. By changing the value of the base resistor, the operating point can be changed.

Rl - The load resistor is used to develop the output signal and to develop the collector voltage for the transistor.

REFER TO FIGURE 14

STATIC STATE:

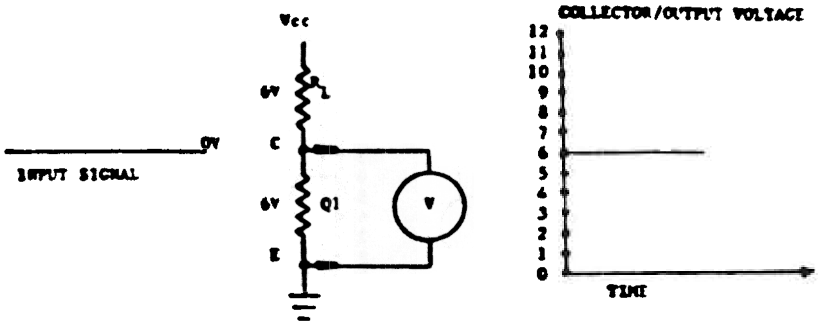
If the DC biasing voltage is applied to the circuit but no input AC signal is applied, the circuit is operating in a static state. The base of the transistor is at some positive potential compared to the emitter. The amount of the positive potential depends on the value of the Vcc and the base resistor (Rb). The transistor will be forward biased and current will flow from the emitter thru the base and thru the collector. With current flowing through the transistor collector and the load resistor, a voltage drop will be developed across the load resistor. The Vcc is connected to the load resistor which is in series with the collector of the transistor, this means the collector voltage will be lower the Vcc because of the voltage dropped across the load resistor. For example, if the Vcc is +12VDC and R1 develops a voltage drop of 6VDC, the collector voltages will be +6VDC. This is the static state voltage value of the collector. This will remain constant unless something within the circuit changes value or an AC input is applied. If the resistance value of the base resistor is decreased, an increase in the positive potential will be felt on the base and cause the transistor to conduct more. The load resistor will develop a larger voltage drop and the collector voltage will be lower in the static state. If the base resistor is increased in value, the transistor will conduct less, causing the voltage drop across the load resistor to be less and the collector voltage to increase.

DYNAMIC STATE

In the dynamic mode all DC biasing voltages are present as described above, the only change will be to apply an AC signal to the input. C1 is the input coupling capacitor. C1 is used to block any DC voltage that is felt on the base of the transistor from being fed back to the generator and causing damage to the generator. It also is used to block current flow from the generator to the Vcc source. If the resistance of the base-emitter junction is higher than the resistance of the signal source, then current will flow from the generator through the base resistor to the Vcc source. This would cause the transistor to cutoff.

The input signal is coupled across C1 to the base of the transistor. When the positive half of the input is felt on the base, it adds to the positive voltage that is present from the static state and causes forward bias to increase on the base, the current flow through the emitter will increase. The base and collector current also will increase. If the current in the collector circuit increases, the load resistor will drop more voltage causing the collector voltage to decrease in value. All this occurs because the base current has changed, remember the base current in a transistor controls the collector current. When the negative half of the input signal is coupled to the base, the negative going signal opposes the DC bias and causes the transistor to decrease in conduction. If the DC voltage is decreased, then the current in the base, emitter and collector will decrease. The decrease in current flow through the collector will cause less voltage to be dropped across the load resistor and a higher voltage value to be felt on the collector.

REFER TO FIGURE 15



STATIC STATE

Figure 15

Kirchhoff's voltage law states that when calculating the circuit voltage, the voltage drops across the loads in any closed loop must add up to the total supply voltage. This says that the entire 12 volts applied as Vcc must be dropped across the circuit. If the load resistor drops 6V of the Vcc, the collector-emitter junction must drop the other 6 volts.

In the dynamic mode, the input AC signal is causing the base current to vary. This causes the collector current to vary and also causes the voltage drop across the load resistor to change. If the voltage drop across the load resistor changes, the voltage drop across the transistor will also change. The presence of the varying voltage on the collector will characterize the transistor as a variable resistor.

REFER TO FIGURE 16.

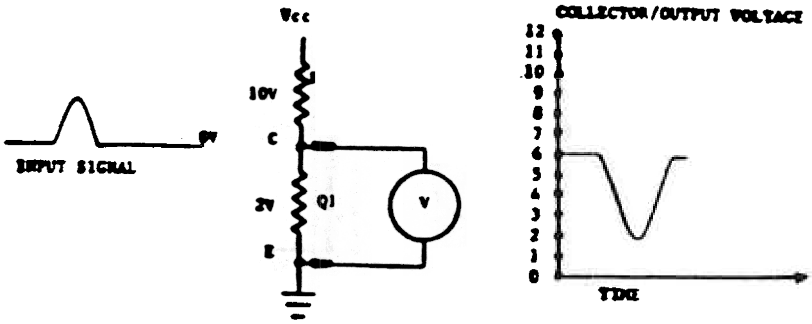


Figure 16

When the positive portion of the input signal is felt on the base, it will increase the forward bias of the transistor. If the forward bias is increased, the resistance of the heavily conducting transistor will decrease. Under this condition the collector-emitter junction will drop less voltage and the load resistor will drop more voltage.

REFER TO FIGURE 17

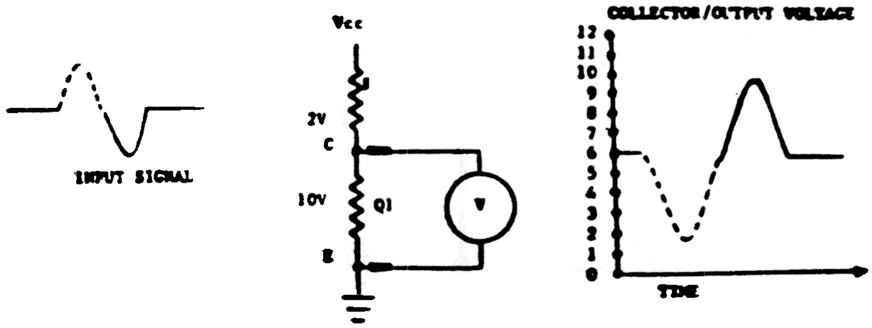


Figure 17

When the negative portion of the input signal is felt on the base, it will oppose the forward bias and cause the transistor to decrease in conduction. If the forward bias is decreased, the resistance of the transistor will increase and cause the collector-emitter junction to drop more voltage.

Notice the output signal is 180 degrees out of phase from the input. This is due to changing the conduction level of the transistor. The input signal is not being transferred across the transistor, it simple changes the biasing of the transistor and either causes more of less current to flow through the transistor. The output signal is developed by causing a changing voltage drop across the transistor. The output is the DC voltage on the collector being varied at an AC rate by the input signal applied to the base.

The signal in Figure 17 is an exact replica of the input signal except for the phase and amplitude. When an amplifier develops a signal like this, it is known as a linear amplifier. If the output signal is not an amplified replica it is known as a nonlinear amplifier. Class AB, B, and C Amplifiers have some distortion in the output, so they are nonlinear amplifiers. The distortion is caused by the amplifier being driven into saturation or cutoff.

COMMON BASE AMPLIFIERS

REFER TO FIGURE 18

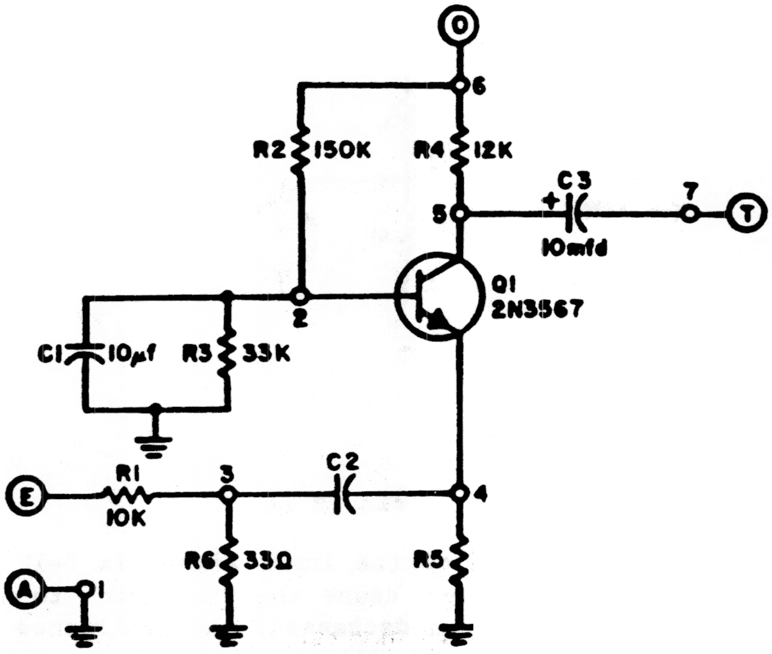


Figure 18

The Common-Base Amplifier receives the input signal on the emitter and the output is taken from the collector. With no signal to this circuit, the collector will have a constant positive voltage, the base will have some small positive voltage that will be developed by the bias network of R1 and R2 and the emitter will have a voltage which will be less positive than the base.

The Common-Base Amplifier is mainly used for impedance matching. It has a low input impedance and a high output impedance. Impedance is defined as the total resistance offered to an AC signal. Input impedance is the loading effect the amplifier will present to the signal source.

REFER TO FIGURE 19

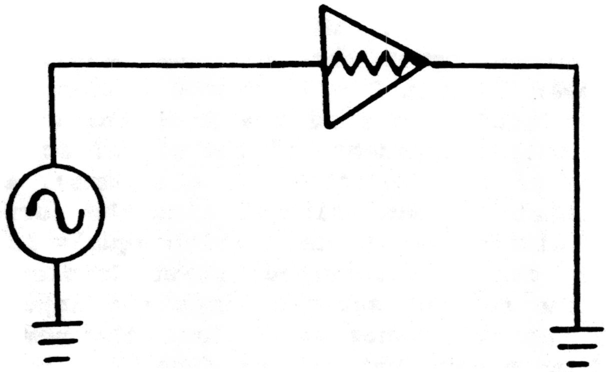


Figure 19

When the amplifier is connected to the signal source, the signal source sees the amplifier as a load, not as an amplifier. The load seen by the signal source is the input impedance of the amplifier. Different amplifiers, that is, amplifiers with different component values, will have different impedance values. Signal sources will also have different output impedance values. For example, the Hewlett-Packard Function Generator, Model 3311A, has an output impedance of 600 ohms and the VIZ Generator, Model WR-50C, has an output impedance of approximately 10,000 ohms. If the maximum signal is to be transferred from the signal source to the input of the amplifier, the resistances of the signal source and the amplifier must be equal. The process of making impedances matching is important because of power developed by the amplifier. If the output impedance of the signal source and the input impedance of the amplifier is matched, the amplifier will develop maximum power.

REFER TO FIGURE 20.

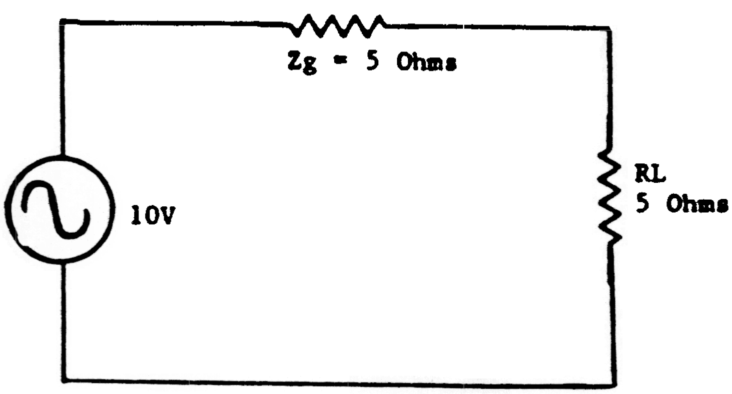
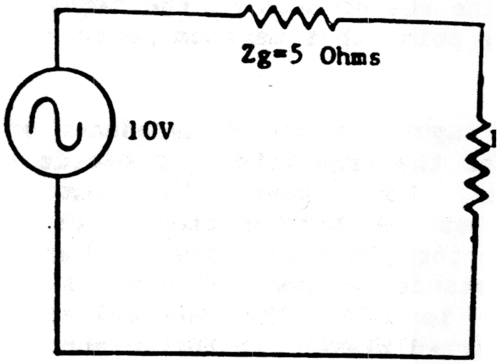


Figure 20

The output voltage from the signal source is 10 volts and the output impedance of the signal source is 5 ohms (Zg). The amplifier has an output impedance of 5 ohms (Rl). With this information it is possible to determine the amount of power that will be developed by the amplifier. Using the basic power formula P = I squared X R and Ohms's Law, the circuit values can be found. To find the R of the circuit, simply add the resistances of the output impedance of the signal source (Zg = 5 ohms) and the input impedance of the amplifier (Rl = 5 ohms), so R equals 10 ohms. Then, using the resistance and voltage, find the current. I = E divided by R, which is 10V divided by 10 ohms, which equals 1A. Now that the current is known power can be determined, power developed across the amplifier is equal to the current squared times the input impedance. If the current is 1A and the resistance is 5 ohms, the power is 5 watts. So 5 watts is the maximum power that can be developed by this amplifier. If the input impedance of the amplifier is changed, the power will decrease.

REFER TO FIGURE 21.

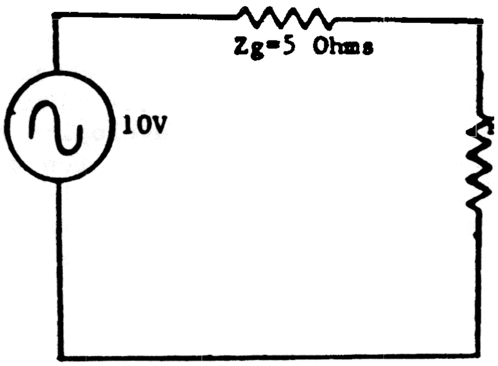


$I = \frac{E}{R}$ $P = I^2 \times R_1$

$I = \frac{10}{6}$ $P = 1.6^2 \times 1$

$I = 1.6A$ $P = 2.56 \times 1$

$P = 2.56W$



$I = \frac{E}{R}$ $P = I^2 \times R1$

$I = \frac{10}{15}$ $P = .666^2 \times 10$

$I = .666A$ $P = .444 \times 10$

$P = 4.4W$

Figure 21

The point where the resistances of the signal source and the amplifier are equal is the only point that maximum power can be developed across the amplifier.

To determine the input and output impedance of an amplifier, look for the common terminal of the transistor and decide how the input and output signals are developed. For example, the Common-Base Amplifier develops the input signal across the base-emitter junction and the output signal across the base-collector junction. The base-emitter junction is forward biased thus the resistance is low. This means the input impedance for a Common-Base Amplifier is low. The base-collector junction of a Common Base Amplifier is reversed biased, so the output impedance will be high.

STATIC STATE (NO INPUT)

With no input signal applied to the emitter, the transistor will be forward biased and will conduct. When the operating voltage is applied at pin 0, current will flow from the ground at the bottom of R3 thru R2 to the power source.

This current will develop a low positive voltage at TP2. The positive voltage at TP2 (approximately 2 volts) will forward bias Q1 and cause it to conduct. When Q1 conducts, current will flow from ground thru R5, Q1 and R4. This current flow will develop a small positive voltage on the emitter of Q1. This voltage will be approximately 1.4 volts. Also this current will cause a voltage drop across R4 of about 4.8 volts, this leaves approximately 7.2 volts, which is felt on the collector or Q1. The transistor will stay in this state until a signal is applied to the emitter. R2 and R3 are the bias developing resistors for Q1 and establish the operating point of Q1. To change the operating point of this amplifier, one of these resistors must be changed. If the operating point is changed, the amplifier can be changed from one class of operation to another class of operation. (From Class A to Class AB)

DYNAMIC STATE

With an AC signal applied to the Common-Base Amplifier, the conduction of the transistor is constantly changing. If the conduction is changing the output will also change.

REFER TO FIGURE 18.

The input signal is applied to the emitter of the transistor thru coupling capacitor C2. When the positive alternation of the input signal is felt on the emitter, the positive voltage of the input will add to the voltage that was developed on the emitter during the static state. If these added voltages are larger than the voltage on the base, the transistor will be driven to cutoff and will not be conducting in the Class A mode of operation. If the voltage on the base during the static state is 2 volts and the emitter voltage is 1.4 volts, the maximum amplitude of the positive peak can be no larger than .6 volts in amplitude and still remain a Class A Amplifier.

When the positive signal is applied to the emitter, a difference in the biasing voltage will occur. If the base voltage was 2 volts and the emitter voltage was 1.4 volts in the static mode, the bias is .6 volts. If the positive signal applied to the emitter has a positive peak of 30 millivolts, the difference is now .57 volts. This is a small change in voltage but this change will cause the transistor to change the rate of conduction. If the differences of potential between the base and emitter varies even a small amount, it will cause the transistor to vary its conduction level greatly. (Refer to the load line Figure 12). With the difference of potential between the base and emitter decreased, the conduction of the transistor will decrease. Using Ohm's Law, if the voltage decreases, the current will decrease if resistance remains constant. The base-emitter junction is forward biased at both points (.6 volts and .57 volts difference) so resistance will remain fairly constant. The difference of potential decreased, which means the current thru the transistor decreased. If the current decreases in the collector, the voltage drop across the load resistor (R4) will decrease causing the voltage at the output to increase.

During the negative alternation, the input signal will have the opposite effect on the transistor. When the negative signal is applied to the emitter, the negative will subtract from the positive voltage on the emitter, causing the difference of potential between the base and emitter to increase. In the static state the bias was .6 volts, if the negative signal has a negative peak of 30 millivolts, the difference of potential becomes .63 volts, causing the transistor to conduct more. If the voltage increases, the current will increase, causing more voltage to be dropped across the load resistor (R4) and less voltage at the output.

If the input is applied to the emitter and the output is taken from the collector. This amplifier cannot amplify current. Remember that 100% of the current is felt in the emitter, but only 95% of the current is felt in the collector. This indicates the current gain has to be less than one because the collector will never feel 100% of the current. The small input voltage to the emitter did cause a large change in the voltage on the collector, so this type amplifier will have a high voltage gain.

The Common-Base Amplifier operates good in the high frequency range which makes it extremely useful is television Preamplifiers and FM Tuners.

REFER TO FIGURE 18.

R2 and R3 establishes the base bias voltage to determine the operating point of Q1. C1 is a bypass capacitor. If any AC signal is felt at TP2 it would change the operating point or base bias and cause the conduction of Q1 to change. The capacitor places TP2 at ground level to an AC signal, thus the DC voltage at TP2 will remain constant. R1 and R6 establish the amplitude of the input signal.

COMMON COLLECTOR AMPLIFIER

The input signal is placed on the base of a common collector the same as was done for a common emitter, but the output is taken from the emitter. The input impedance is high for a Common Collector because of the reverse bias of the base-collector junction. The output impedance is low because of the bypass capacitor which is normally placed in the collector circuit or the low resistance to AC offered by the power supply, which only leaves the load resistor in the emitter and the resistance of the conducting transistor for an output impedance.

The Common-Collector Amplifier has no phase shift between the input and output signals. Also the voltage gain will always be less than one, but the current gain will be good. The amount of current on the base, which is the input, is much less than the current in the emitter, which is the output.

The Common-Collector Amplifier is sometimes referred to as an Emitter Follower. If the voltage on the base goes positive, the emitter voltage will follow the base voltage.

The Common-Collector Amplifier is mostly used for impedance matching and as Isolation Amplifiers. If the input signal is low in amplitude, all of the input signal will be dropped across the high impedance input and there will be no output signal. The high impedance at the input causes very little current to flow between the input source and the amplifier, so it isolates the signal from each stage.

REFER TO FIGURE 22

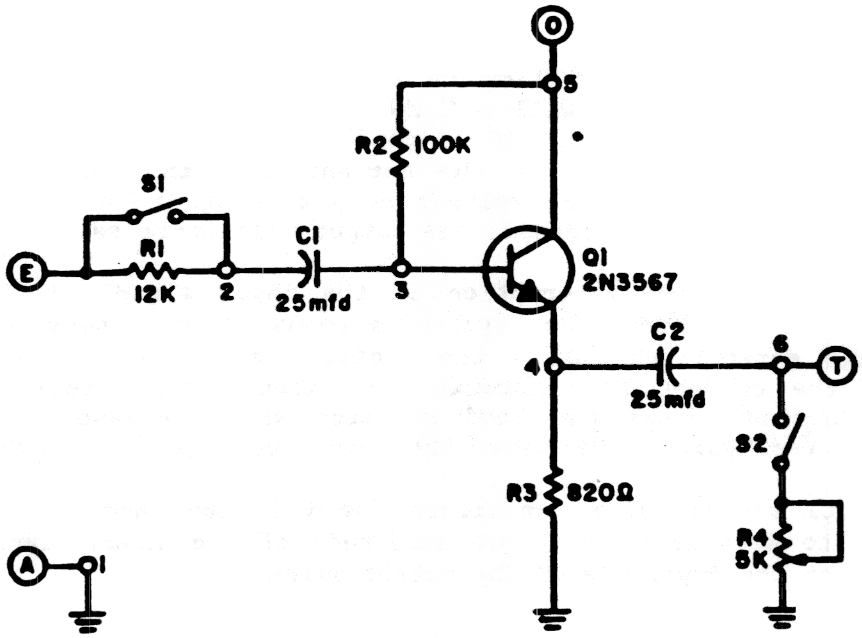


Figure 22

STATIC STATE

With no input signal to the base of the Common-Collector Amplifier and DC voltage applied, a bias voltage will be developed across R2 to the base of Q1. With a positive 12VDC applied to pin O, R2 will drop 6.74VDC and place 5.26VDC on the base of Q1. With this +5.26VDC applied to the base, Q1 will conduct. Current will flow from ground thru load resistor R3 and develop a voltage drop of 4.51VDC. This 4.51VDC will be felt on the emitter and Q1 will continue to conduct until some change is made to the circuit or the power is removed.

DYNAMIC STATE

When the positive alternation of the input signal is applied to the base of the transistor, it will aid the forward bias of Q1 and cause the transistor to conduct harder. If Q1 conducts more, the current flow will increase thru the circuit. If the current thru the load resistor increases, it will develop more voltage drop causing the output voltage to increase. If the input increases, the output will increase.

During the negative alternation of the input signal, the base bias voltage will be decreased, the negative alternation will subtract from the bias voltage established during the static state. If the bias voltage decreases, the current flow through the circuit will decrease and the voltage developed across the load resistor will decrease in amplitude. Again if the base voltage decreases the output voltage will decrease.

C1 and C2 are coupling capacitors for the input and output signals. R1 is used to determine the input amplitude of the input signal. R4 is used to adjust the amplitude of the output signal.